DOCUMENT RESUME

ED 121 285 IR 003 262

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TITLE CMRE: Computer Managed Review and Examination.
INSTITUTION Pennsylvania State Univ., University Park. Computer-Assisted Instruction Lab.
SPONS AGENCY Health Resources Administration (DHEW/PHS), Bethesda, Md. Bureau of Health Resources Development.
PUB DATE Apr 76
NOTE 26p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, California, April 19-23, 1976)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage
DESCRIPTORS *Computer Assisted Instruction; *Criterion Referenced Tests; External Degree Programs; Flow Charts; Higher Education; *Inservice Education; Program Descriptions; Testing
IDENTIFIERS *Computer Managed Review and Examination; Pennsylvania State University

ABSTRACT

The Computer Managed Review and Examination System (CMRE) is described as a sophisticated form of computer-managed instruction designed to meet the needs of students who have some knowledge of the subject matter in a course of study, but may need to review material on some topics and increase their knowledge of others. The program incorporates a diagnostic pretest to identify which material the student should study, a computer managed review to help make up deficiencies, and a criterion-referenced comprehensive final examination. It also provides for supplementary examinations if the student fails to meet criterion for any particular module. The student learns from textual material "off-line" but interacts with the computer during the review session and during all tests. A flow diagram of the CMRE model and a detailed description of how a student would use it is included. (Author/JY)

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CMRE: COMPUTER MANAGED REVIEW AND EXAMINATION*

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Abstract

The Computer Managed Review and Examination (CMRE) System is described as a sophisticated form of computer managed instruction designed to meet the needs of students who have some knowledge of the subject matter in a course of study, but may need to review material on some topics and increase their knowledge of others. The program incorporates a diagnostic pretest to identify which material the student should study, a computer managed review to help make up deficiencies, and a criterion-referenced comprehensive final examination. It also provides for supplementary examinations if the student fails to meet criterion for any particular module. The student learns from textual material "off-line" but interacts with the computer during the study managed review and during all tests. A flow diagram of the CMRE model and a detailed description of how a student would use it is included.

It is believed that CMRE is an effective method of enabling students to obtain credit for prior knowledge and experience while alleviating some of the difficulties posed by traditional credit-by-examination. The use of CMI Systems such as CMRE also has wide application for resident instruction.

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The Computer Managed Review and Examination (CMRE) System was developed at The Pennsylvania State University for use in a project entitled "Mobile Education for Nurses in Remote Areas".[2] The CMRE system is a sophisticated form of computer managed instruction designed

*Presented at the 1976 AERA Annual Meeting, San Francisco, California, April, 1976.

[2]This project was funded by the Bureau of Health Resources and Development in The Public Health Service, a subdivision of the U.S. Department of Health, Education and Welfare. Contract No. 03D-005335-02-1.

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to meet the needs of students who have some knowledge of the subject matter in a course of study, but may need to review material in some subjects and increase their knowledge in others. Seven undergraduate level nursing courses have been developed to date using the CMRE framework.

A proposal to the Public Health Service for the project-Mobile Education for Nurses in Remote Areas-included a provision for developing examinations which the nurses could take on a computer in certain subject matter areas and thus receive credit by examination. A transportable learning center, which consists of an IBM 1500 Instructional System complete with student terminals housed in a specially designed van, was to be used as the delivery system. While the system of credit by examination is a viable method of enabling a student to earn credit for previous work, it does have certain limitations. This is particularly the case at Penn State where a student who fails a credit by examination must enroll in the corresponding Resident Instruction course. In addition, the curriculum for which the nurse is responsible is often poorly defined and the student is uncertain as to what level of mastery is required. Because the registered nurses who wish to obtain baccalaureate degrees all have had considerable training in nursing, there was a need to devise a system which not only tested their current ability but also helped them to supplement their knowledge in order to obtain degree credit. There was also a need to reassure the degree granting institution that the student can deomonstrate competency before credit is given.

Consequently, it was decided to combine a diagnostic pretest to help the student identify the material which he needs to study, a computer managed review to help him to make up deficiencies and a domain-referenced comprehensive final to meet the academic requirements of the Nursing Department. Thus, the Computer Managed Review and Examination (CMRE) System was designed to help nurse-students obtain college credit while assuring specified level of competence.

Design Considerations

Since the nurse students would be utilizing CMRE in areas where nursing faculty members were not readily available and library facilities might not be easily accessible, there was a need to provide the students with study materials which covered the entire curriculum. For practical reasons, it was decided to use only textual material initially. One of the main problems encountered in the early stages of the project was to decide on exactly which textual materials should be included in each course. The faculty member as the course author decided on what materials were to be used but only after consultation with other faculty members and the approval of the curriculum in general by a departmental committee.

One problem associated with the exclusive use of textual material, was that the reading material assigned to the students might be very difficult for the student to master without the aid of an instructor. The initial design called for the student to reread and restudy the

material on which he was unable to demonstrate competency. However, the formative evaluation of the program calls for the identification of particularly difficult lessons so that other remediation devices can be used. The program also had to be flexible enough so that a course could be periodically up-dated or revised with a minimum of programming and administration time.

It was decided that the computer managed instruction program should to be designed to make use of the extensive data gathering capability of the computer, so that individual courses could be continually evaluated and improved. Each course also had to be organized in a way which facilitated the gathering of formative evaluation data as well as keeping accurate records of individual student performance.

Organization of CMRE Courses

In order to fit into the CMRE model, each nursing course is divided into modules and each module is divided into lessons. Specific textual materials from nursing textbooks, other textbooks, and appropriate journal articles are assigned for each lesson. The nurse, therefore knows ahead of time the exact content domain for which he is responsible. Since the curriculum for these courses is approximately the same as that for Resident Instruction in the nursing department, it is possible to insure that the registered nurse who uses the CMRE System receives undergraduate credit by demonstrating approximately the same competency as a regular full-time student in the nursing department.

This can be done by basing the criteria or standards for the CMRE course on what is considered to be an acceptable performance by full-time students in an undergraduate nursing program. Although the objectives for each course are specified by the author, the examination items are tied to specific content in the textual material. Since the material for each course is clearly defined, the examinations are "domain-referenced" as defined by Millman (1974) and not criterion-referenced. In this paper, the standards of performance set by the authors to delineate levels of competency are sometimes referred to as "criteria".

Because the course is conveniently divided into modules and lessons, it is possible to evaluate the performance of each student in each individual module. Utilizing this feature, the design of the CMRE program makes it impossible for students to obtain credit for a course until they have demonstrated competency in every area that the course author requires. This is done by making provision for modular supplementary examinations by which a student can improve his performance on modules where he has not met the standard on the final examination.

Each computer-managed instruction course utilizing the CMRE model consists of the following components:

1. A diagnostic pretest which is used to determine what modules the student should study before taking the final examination.

2. A computer managed review to enable all students to supplement their knowledge of course materials or to review previous learning in any particular module.
3. A comprehensive final examination covering all the material included in the domain of the course.
4. Provision for separate supplementary examinations covering the material from each module.

These four basic components are described in detail in the following pages.

The Diagnostic Pretest

The purpose of the Diagnostic Pretest is to help to determine which of the modules a particular student should study. Because much of the material in a course may have been previously learned in a nursing diploma school or elsewhere, the pretest enables a knowledgable nurse-student to skip many of the modules. Thus, study time is spent primarily in areas which are not well known. The Diagnostic Pretest consists of approximately 100 to 120 items randomly sampled by lesson and module from the examination question pool.

Based primarily on the performance of regular full-time nursing students, an upper and a lower standard for each module is set by the course author. As soon as the student finishes the pretest, a table showing his performance on each module appears on the cathode ray tube

(CRT) screen. After each module designator one of the following categories will appear:

1. SUPERIOR: Performance was above the upper standard and further study of this module is not required.
2. ADEQUATE: Performance was above the lower standard but below the upper standard. The student has the option of taking the Computer Managed Review.
3. BELOW STANDARD: Performance was below the lower standard and the student must take the Computer Managed Review for this module before he takes the final examination.

Thus, the student knows immediately after he takes the pretest, how many modules he will bypass, how many he must study using the Computer Managed Review, and how many are optional. A particularly knowledgable student whose performance was SUPERIOR or ADEQUATE on all modules would be allowed to take the final examination immediately. He may however, choose to utilize the Computer Managed Review for some modules, and he may also wish to study the textual material at home before taking the final examination at a later time of his choosing.

After the Diagnostic Pretest results are obtained, the student must first take the Computer Managed Review for all the "BELOW STANDARD" modules. Where his performance was judged to be ADEQUATE

he will be asked, one module at a time, whether or not he wishes to take the Computer Managed Review. Since he has access to all textual material on which the modules are based, this decision could be an enlightened one.

The Computer Managed Review (CMR)

The function of the Computer Managed Review is to help the student to review material which he may have previously studied and to facilitate his learning of new material. This is considered to be of prime importance since so many of the nurse-students may have been away from the classroom for some time and faculty members are not normally available at the mobile site to motivate or assist them. Since the relearning time is often a small fraction of the original learning time, the amount of time spent using CMR for a particular module may vary widely between students.

The CMR portion of the CMRE system is modeled closely after the Computer Aided Instruction Study Management System (CAISMS) developed and currently being used for an introductory economics course at The University of Illinois (Anderson, et al., 1974; Anderson, et al., 1975.) The theoretical justification for this type of system is eloquently outlined by Richard C. Anderson (1974) and the previously cited articles. As has been pointed out, asking a student questions immediately after he studies a prose passage is not a new idea, but a considerable volume of research indicates that it is an effective strategy (Rothkopf,

1966; Rothkopf and Bisbicos, 1967; Frase, 1968.) One might add that this appears to be one area where most educational psychologists would agree that beneficial results can be obtained. When using the Computer Managed Review, the students know that they will be asked questions after they read each assignment and that they cannot proceed until they can answer most of these questions. This strategy is designed to motivate them to study the material carefully.

When a student begins the CMR for any given module, he receives the assignment for lesson A at the student terminal and then is signed off for at least 20 minutes so he can study the material. Normally this studying will be done in a designated study area near the student terminals. The assignment for one lesson is expected to take from 20 minutes to an hour or more depending on the length and difficulty of the material and the students background. After he has studied this material, the student signs back onto the computer and is asked from 6-12 review questions. Although all students get the same questions, they are presented in random order. As soon as a student misses more than 30% of the questions and can no longer meet the criterion (usually 70%) he is asked to restudy the material and is signed-off.

The review questions are designed to interrogate the student concerning any major concepts or important ideas contained in the reading assignment. However, this is not always feasible and the author may write any constructed response or multiple choice question he thinks is appropriate. Although the questions are not drawn from the

examination pool, items concerning the same content may appear on the final examination. At any rate, the student should benefit by both the direct and indirect effects of this questioning.

At the time of this writing, if a student fails to answer 70% of the review questions, he has no recourse but to restudy the textual material. However, as difficult lessons are identified from the computer stored data, other methods of remediation such as a short tutorial CAI segment, audio tapes, or film strips will be considered. If he answers all the questions correctly, he will be given the assignment for the next lesson immediately. If his score is over 70% but less than 100% he is given the option of going on or repeating the lesson. If he chooses not to repeat the lesson, he is given the questions he missed together with a prescription (the exact page or pages from which the answer can be deduced for remediating his work.) After the student has completed the CMR for all modules for which it is compulsory and those he chooses voluntarily, he is ready for the final examination.

The Comprehensive Final Examination

Each student's final examination is constructed by randomly sampling by lesson and module from the examination item pool. Since the number of items from each lesson which will appear on the final exam has been specified by the author a priori, based on the length, difficulty, and importance of the material, content validity is virtually assured. Each examination consists of approximately 180 items drawn from a question pool four times that size. Because

examinations are scheduled on an individual basis, attempts at cheating during the examination are not likely to be profitable. As the items on the final examination cover all of the materials assigned during the course, information as to what areas a particular examination covers would not be very helpful to a student taking the exam at a later date. In addition, the proctors insure that students using CMRE do not copy questions.

Although some educators may insist that the students take the examination at one sitting, a student can stop after answering any number of questions and continue the exam at a later time. This is possible because the computer keeps a continuous record of how many and which questions have been asked as well as the student's performance. Later the student is provided with more randomly sampled items beginning where he left off. The student is usually given as much time as he needs to complete the examination. This appears to relieve test anxiety particularly among older students who have been away from educational settings for some time. Data on all CMRE examinations given to date indicate that there is an nonsignificant (close to zero) correlation between the time taken to complete the examination and the final score, when students are allowed as much time as they wish.

Immediately after the final examination, a table of results is displayed indicating the student's performance on each module. If the student has met the standard on all modules he is congratulated for passing the course and told he will be assigned a letter grade at a

later date by a faculty member. Although pass standards for each module are set ahead of time, individual faculty members can use any standards they wish for deciding on a letter grade. Before beginning the course, all students are informed that the grades are based primarily on the performance on the final examination. Before he can pass the course, each student is required to meet the standard for each module. Some institutions might prefer not to assign a letter grade. If the student fails to meet the criteria on one or more modules, he must take a separate supplementary examination on each module missed.

Supplementary Modular Examinations

A student who does not meet the standard for a module will be forced to take the Computer Managed Review for that module and then take a supplementary examination based on the material in that module alone. This is done to insure that the students demonstrate an acceptable level of competence in all areas of the course. The student may have taken the Computer Managed Review previously but he also may have decided not to review this module. The supplementary exam is also randomly sampled from the exam pool and it contains at least as many questions from that module as did the final exam and in the case of short modules, it will contain more questions.

If the student happens to fail the supplementary exam, he must take the Computer Managed Review again and then take another examination. At this time, no limit has been set as to how often a student can take a

supplementary examination. It may be argued that if he takes the examination often enough he will eventually be able to learn the answers to nearly all the questions in the examination pool from that module. Since the questions in the extensive examination pool should cover most of the important material in that module, there should be no qualms about certifying competency in this case. When lesser grades are given, students are told that they can not improve their grade by their performance on supplemental examinations.

The General Student Model

A flow diagram of the general student model and a brief description of its use is included in Appendix A.

Uses of The CMRE Nursing Courses and The CMRE Mode

Although the seven computer-managed instruction courses using the CMRE framework developed at The Pennsylvania State University were designed initially for registered nurses in remote areas seeking college credit, many other applications are feasible. Because of the modular construction, segments of courses or adaptations of them could also be taken by health care personnel other than nurses. Also, because of the transportability of the computer-based instruction, these courses could be made available throughout the United States for the continuing education of nurses. Since the "domain" of the curriculum is precisely defined, other institutions could use parts of courses

or combine sections of different courses and given whatever credit they think is appropriate.

While the courses were being prepared for the IBM 1500 instructional system, care was taken to make them easily adaptable to other computer systems. To this end the audio unit and the image projector were not used for any of the CMRE courses. In addition, only keyboard responses were solicited to eliminate the necessity of a light pen. Consequently, the availability of these courses can be greatly increased by adapting them for large general purpose computer systems, and hence useable at many major universities.

Although the main delivery system at present is the transmobile computer-based instruction unit, the CMRE courses are also being taken at Penn State in lieu of credit-by examination by a number of registered nurses in the regular undergraduate program. The Diagnostic Pretest can also be bypassed so that CMRE courses can be made available to undergraduate nursing students as regular courses. The nursing faculty members released from lecturing duties by this strategy could then spend more time interacting with individual students or conducting small-group seminars on current nursing issues. This is being done at The University of Illinois, where seminars are conducted by economics faculty whose students are using a computer-based study management system instead of attending lectures. The thought of eliminating lectures altogether may be considered to be inappropriate by some educators, but it has been successful at many colleges. The results of a questionnaire study of 190 courses using self-instruction

materials was reported in the June, 1972 issue of the Personalized System of Instruction Newsletter. Although in most of these courses, which covered a wide range of disciplines, lectures were entirely eliminated, only 3 of 190 were said to have been failures. Students were reported to heavily prefer the self-instruction mode when compared with lectures and almost all respondents also claimed that the students learned more.

In summary, it appears that CMRE is an effective method of enabling students to obtain credit for prior knowledge and experience while alleviating some of the difficulties posed by traditional credit-by-examination. It is also considered to be an efficient use of computer facilities as the student learns primarily by studying textual material. However, the CMRE program does make provisions for the use of tutorial CAI segments for subject matter which is difficult for an individual to learn from a textbook or article.

Courses using CMRE can be updated or improved with a relatively small programming effort. Improvements can be based on the substantial amount of data which the computer gathers on all students. Since the "domain" of CMRE courses is clearly defined, students know exactly what material they are responsible for and the content validity of examinations is assured.

The use of CMI systems such as CMRE is also suitable for resident instruction, and early indications are that they compare favorably with the lecture-discussion mode of instruction (Anderson

et al., 1975). However, when used with regular undergraduate nursing students, some courses will indoubtedly need to be supplemented with clinical training. They would however, release experienced faculty members from lecturing duties and enable them to spend more time with students in the clinic and other small group sessions.

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APPENDIX A

THE GENERAL STUDENT MODEL

The General Student Model

Since the same general model is used for all seven nursing courses developed to date, it might be appropriate to follow a nurse-student through a typical course. This will be done by referring to the flow diagram of the general model (Figure 1) and the detailed flow diagrams of the Computer Managed Review (Figure 2) and the supplemental examinations. (Figure 3) The letters and numbers referred to in this description can readily be identified on the appropriate diagrams.

A. Before he sits down at the student terminal, the student is given a full explanation of how the CMRE program operates. He learns the function of the Diagnostic Pretest, the Computer Managed Review, the Final Examination, and the Supplemental Modular Examinations. He is assured that both the Diagnostic Pretest and the Computer Managed Review are there to help him and are not included in the evaluation of his performance on the course.

B. When the student first signs on to the computer, he is taught how to operate the terminal - an uncomplicated procedure - and then given a brief explanation of the CMRE program. A proctor is available continuously in the mobile van or wherever the terminals are located, to assist the

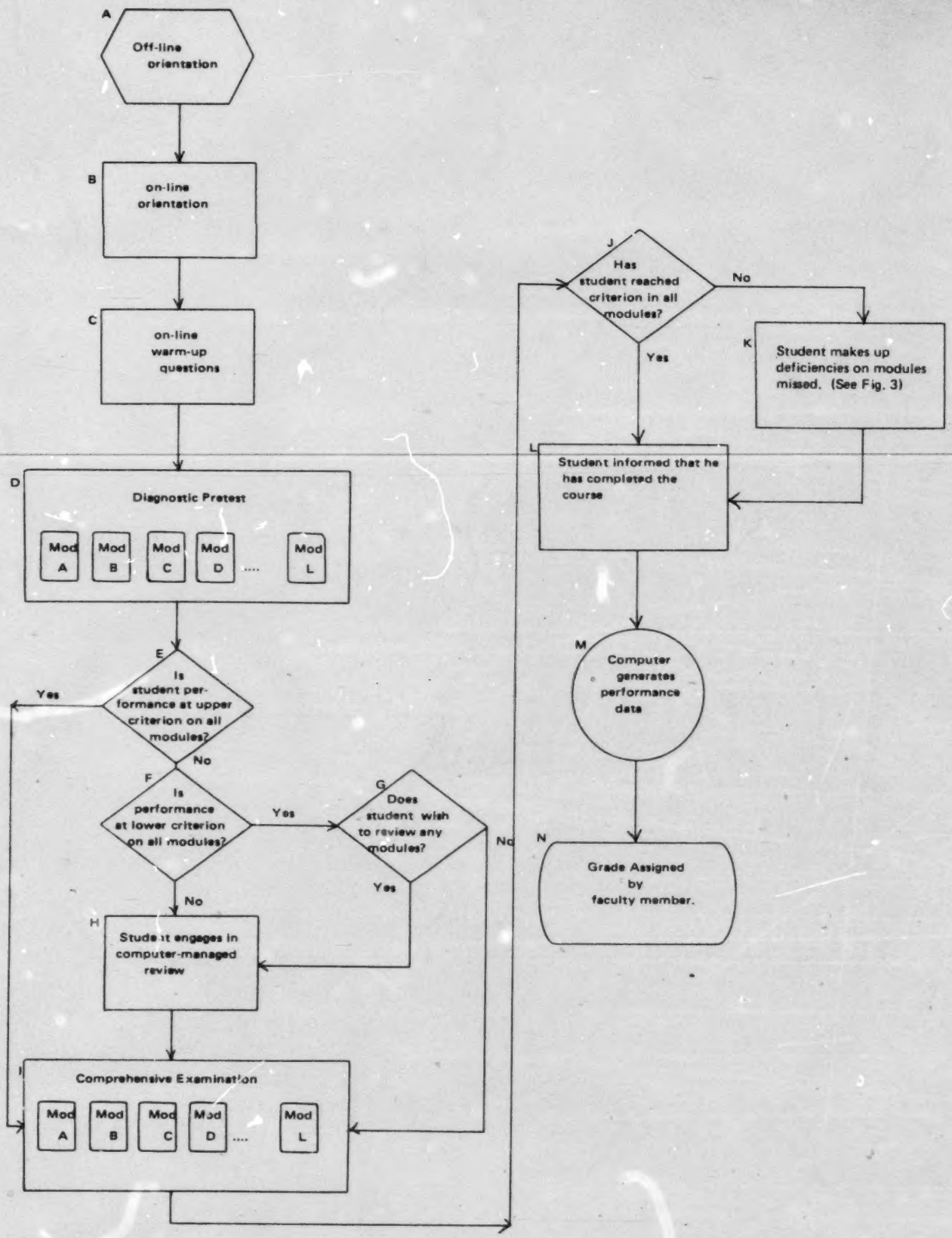

Figure 1. Student Evaluation and Computer-Managed Review Model.

student and to answer questions concerning terminal operation and the general model.

C. Practice questions with nursing content are then used to familiarize the student with the various types of items he will encounter and to prepare him for taking a test using the computer. This is particularly helpful if it is the student's first CMRE course, as he will encounter questions he does not usually find on a typical multiple choice examination. (e.g. Select two or more, select three)

D. The student then takes the Diagnostic Pretest which consists of 100-120 items randomly sampled from each lesson and module. The program is designed to handle up to twelve modules in each course.

E,F,G. His performance has been judged either Superior, Adequate, or Below Standard depending on his performance on each module. If all modules were "Superior" or "Adequate", he could take the Final Exam immediately. However, let us assume that his performance was Superior on seven modules, Adequate on three, and Below Standard on two. The student then takes the Computer

Managed Review on the two "Below Standard" modules, and after perusing the textual material decides to use the computer to help him review two of the three "Adequate" models.

H. Referring to the detailed flow diagram (Figure 2) of the Computer Managed Review process, let us assume that one of the modules missed had three lessons (1). Our student is given the assignment for the first lesson (2), studies it well and gets one hundred percent of the review questions correct (4,5,6). He is given the next assignment, which he studies and answers eight out of ten (80%) correctly on the review quiz. He chooses not to repeat the lesson and is given the prescription for the questions he missed before being assigned the last lesson (7,9,10, 11, 12). After studying the third lesson he answers only fifty percent of the questions correctly and is consequently forced to restudy the material (7,8). After doing so he answers all the review questions correctly and is given the assignment for the first lesson of the next module he must study. After completing the review of all modules, both mandatory and voluntary (13) he is ready to take the Final Examination.

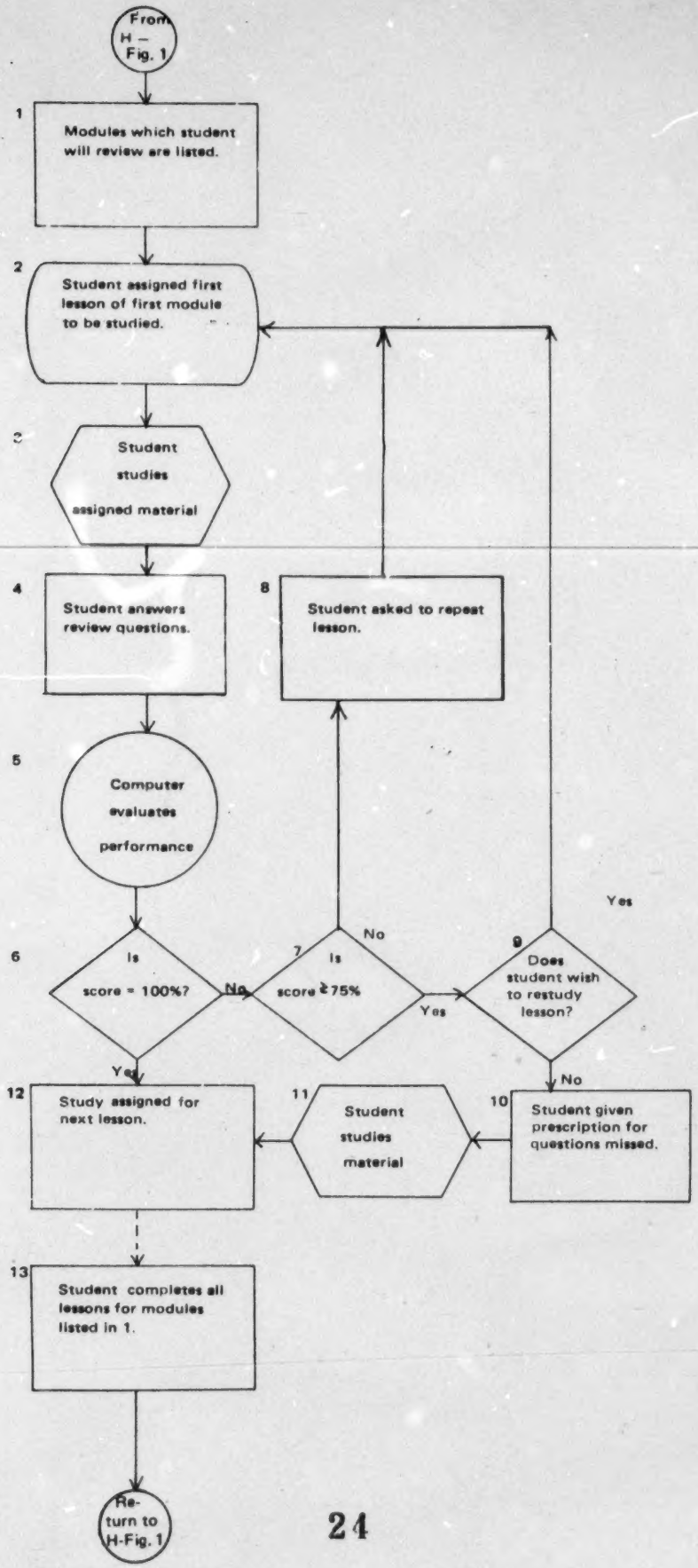

Figure 2. Detailed description of function of Block H. "Computer-Managed Review" of the Student Evaluation and Computer-Managed Review Model.

I. The student takes the Comprehensive Final Examination and meets the standard on all but two modules.

J. In order to complete the course the student must reach criterion on all modules. He is informed of his performance and told he must study and take a supplemental examination on each of two modules.

K. Referring to Figure 3, let us assume that the student has taken the Computer Managed Review for the first module and the supplemental examination (2,3). He is then informed of his performance and also given a prescription for all items missed. After he passes this examination, he is forced to take the CMR for the other module missed (5,1). After studying the material he passes an examination based on this module also.

L,M,N. The student is then informed that he has passed the course and that a faculty member will assign a letter grade based on his performance. The computer generates performance data which will be used by a faculty member to assign the final grade. Additional performance data generated by the computer will be used to evaluate and improve the course.

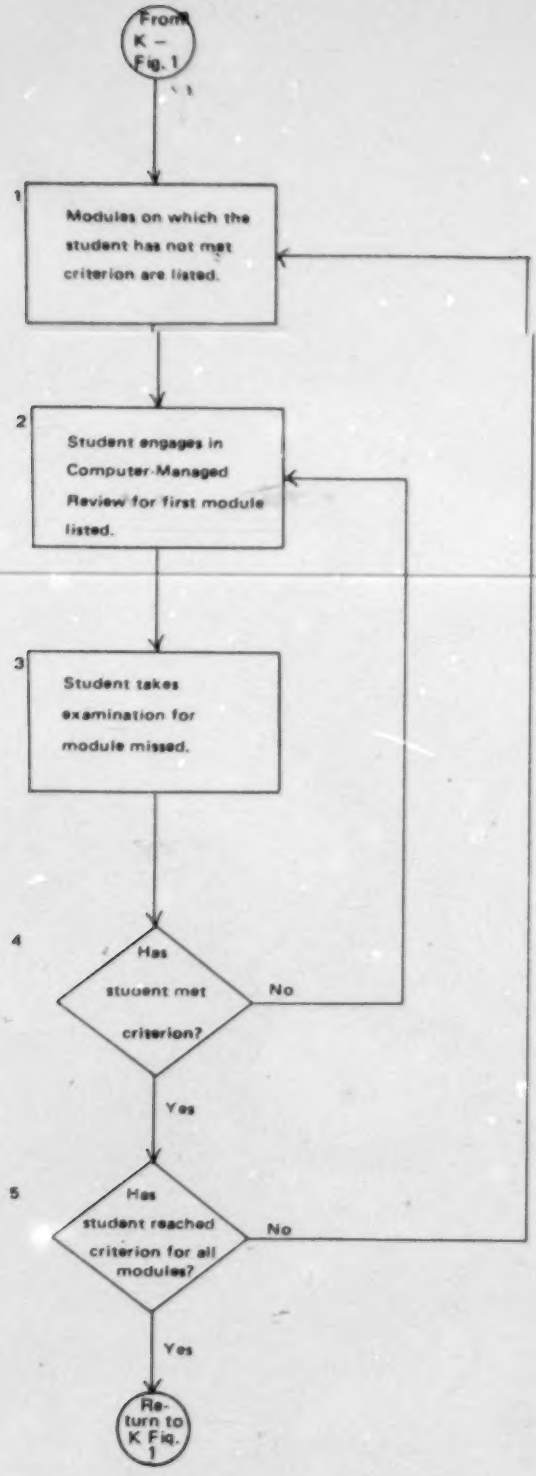

Figure 3. Detailed breakdown of functions in Block K. "Student Deficiencies of Student Evaluation and Computer-Managed Review Model."